bill quoted from Vaurie. A correction from "From Skull" to "From anterior border of nostril" is included in the note sent for publication in the Journal which, moreover, is duly acknowledged to Mr. A. according to his specific stipulation (*JBNHS* 74:357).

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7. PRE-NATAL VOCALIZATION AND IMPRINTING IN BIRDS

For long time, game breeders have known that the eggs of game birds hatch almost simultaneously when incubated by the hen. Game birds like partridge, junglefowl, pheasants and ducks, lay five to twenty eggs. As a rule, only one egg is laid each day and incubation does not start till the clutch is complete. However, due to the fact that these birds breed in summer, preliminary embryonic development of the chick starts by the heat of the atmosphere. Moreover, in order to protect the eggs, the cryptically coloured female starts sitting on the eggs, especially during night. But the female does not cover the eggs completely because the brood patch is not yet fully developed. The brood or incubation patch is an unfeathered area on the ventral side of the body with numerous blood vessels. It is developed to facilitate transfer of body heat to the eggs. By the time all the eggs are layed, the brood patch is completely developed and also gradually increases during brooding. Thus, when actual incubation starts, the first egg is a little more advanced in embryonic development than the last, so that the first egg must normally hatch many hours or even days before the last egg. However, we find that all the eggs hatch synchronously when incubated by the mother. On the other hand, if the same clutch is artificially incubated, the eggs hatch one after the other over a period of two or three days. Certainly the explanation of this discrepency lies in the mother hen.

Through ingenious experiments on mallard duck (*Anas platyrhynchos*), Hess (1972) found that the brooding duck vocalizes regularly during the later part of the incubation period. It seems probable that the mallard is answering to the calls produced by the developing ducklings. However, later it was found that the female duck sitting on the infertile eggs calls as much as those sitting on fertile ones. So, the female itself initiates the vocalization. Moreover, it was also found that sitting on the eggs for three weeks or more triggers certain neuro-endocrine mechanisms as the result of which the female starts vocalizing (Hess 1972). Experiments showed that mallards do not respond to the recorded sounds of pre-hatched ducklings during the first and second week of brooding. In fact, during the initial stages of brooding, the response to recorded sound of duckling is threat behaviour. It is only in the third week that the mother responded to the recorded duckling calls with clucking. In the fourth week, all the females experimented with responded favourably with increase in clucking. Therefore, sitting on the eggs for a certain period stimulates the bird — through hormonal action — to start its clucking calls.

Though, the auditory system in embryonic birds develop quite early, structural development does not imply functional development. Grier *et al.* (1967) in chickens found that the ears start responding to exogenous sounds only after 18 days of incubation. Developmental stages of chicken and duckling are very similar. Any sound produced by the mother be-

fore the functional development of the auditory faculties would be useless as far as the eggs are concerned. That is why the mother mallard does not start vocalizing before the third week of incubation. Through countless generations, the vocalizing pattern has become innate and part of the legacy of inherited behaviour. That is why, the duck vocalizes with the infertile eggs even though she does not receive any response from the dead eggs.

Normal fertile eggs respond to the clucking sound of the mother and a sort of 'conversation' starts between the offsprings and the mother. Gottlieb (1965) has shown that several days before hatching, the head of the fetal chick and of the fetal duckling moves into the air space at the large end of the egg. The fetuses of both birds start uttering low-intensity peeps or cheeps. Before and during hatching, vocalization of both the mother and offsprings increases dramatically, as complementary responses.

Synchronous hatching of young ones has great survival value, especially for precocial birds, because if the discrepancy of hatching between the first egg and the last one is long, say of two to three days, the mother would be in a dilemma whether to 'entertain' the new arrival or to brood the remaining eggs. Precocial juveniles might also start scampering around and get lost. In order to minimize the maternal troubles, nature has provided females with a sort of "brood whistle" coordinate the hatching and rearing of the chicks.

The actual mechanism by which the development of eggs is hastened or delayed, as the case may be, is not yet clear. It is probable that the mother utters a particular call—tentatively called here as "hatching call"—for hatching. Fully developed early chicks perhaps delay hatching and wait for the "hatching call" to synchronize their birth with the late developers.

The mother could identify the various stages of embryonic development by the responses she receives from every egg. When she finds that all the eggs are ready for hatching, she may give the hatching call; in this way, synchrony in hatching may be achieved. This hypothesis opens interesting problems for future researches in this field.

Synchronization of the oestrus cycle in man and in animals is well known. Nurses, young nuns and girls living in hostels and dormitories unknowingly synchronize their menstrual cycles. Female dogs housed together invariably come into heat together. This 'menstrual synchrony' is mediated by pheromones. Synchrony in hatching, however, is not mediated by pheromones. This is proved by the fact that when the parent-young vocal responses are transmitted through microphone-loudspeaker hook-up between the female mallard's nest and the laboratory incubators, eggs in the incubators hatch as synchronously as eggs in nature (Hess 1972).

The mallard duck becomes silent as soon as the young are hatched. This silence lasts from 16 to 32 hours until it is time to leave the nest (Hess 1972). Abandoning the nest with the full armada of duckling is termed as "exodus". During the hatching period, which lasts about an hour, the mother generally vocalizes at the rate of from zero to four calls per one minute intervals, except for few bursts when the maximum calls reach up to 10 per minute. However, as the exodus begins, the mallard quickly builds up a crescendo of between 40 to 65 calls per minute.

Pre- and post-natal auditory stimulation thoroughly imprint the offspring to their mother's vocalization (Gottlieb 1965; Grier *et al.* 1967). The young ones might not recog-

nise her by face but her calls remind them of the comforts of the egg, thus they respond positively towards her voice. Intense auditory and tactile interaction occurs after hatching which greatly helps in cementing the filial bond. Hess (1972) found that the ducklings make considerable effort to be near their parent. And the more difficulty they face in getting nearer to the parent, the greater the filial attachment.

By the time exodus begins, ducklings are deeply imprinted towards their mother's call. Moreover, every female vocalizes differently so every duckling easily recognises its mother. Some mallards regularly emit a single cluck at one-second interval, some cluck in triple or quadruple clusters while others cluck in clusters of different lengths. The ducklings remember their maternal call-pattern and simulate them when they themselves nest. In this way call-pattern is transmitted from generation to generation.

One of the interesting findings reported by Bailey & Ralph (1975) in pheasants (*Phasianus colchicus*) is that the chicks show greater affinity for the sound heard during the final week of embryonic development and response to a particular call is learned and not inherited. This is proved by the fact that if tape-recorded alarm call is played back to the eggs during the final days of incubation, the developing chicks associate it with positive reinforcement of comfort within the eggs, and after hatching they do not run and hide when the alarm-call is heard. On the other hand, they would crouch and hide if the food-gathering call is played to them. Any call which they have not heard during their pre-natal days acts as alarm-call for them. Thus, the call that will be attractive to the chick is determined during pre-hatching days and has little dependence on innate responsiveness.

Though the brooding hen might make many sounds the alarm-call is certainly not uttered while sitting on the eggs, because as soon as danger threatens, a cryptically-coloured female of game bird tries to camouflage herself by remaining silent. If the danger is literally on her head, she stealthily skulks away from the nest and when she has gone a considerable distance, she explodes in a cacophony of cackles or quacks to divert the attention of the predator from the nest. (Some birds, like lapwings, killdeer, etc., feign injury and 'guide' the predator towards themselves but fly away at the last moment before being caught.) As the alarm-call or danger signal is not uttered by the female on the nest, the developing young ones are not accustomed to this sound and when they hear this call in post-natal days they run and hide.

As the pheasant chicks grow, their attraction response to a specific call heard during the pre-natal development starts waning (Bailey & Ralph 1975). This stage occurs between 21 and 28 days of post-hatching and coincides with the age at which chicks become independent from the hen in the wild.

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